PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY
(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

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Applicant's or agent's file reference P478 0010	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. PCT/CA2004/001971	International filing date *(day/month/year)* 16 November 2004 (16-11-2004)	Priority date *(day/month/year)* 17 November 2003 (17-11-2003)
International Patent Classification (IPC) or national classification and IPC IPC: G01P 5/22 ***(2006.01)*** , G06F 17/15 ***(2006.01)*** , G01F 1/712 ***(2006.01)***		
Applicant PHOTON CONTROL INC. ET AL		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 4 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. [X] *(sent to the applicant and to the International Bureau)* a total of 8 sheets, as follows:
      [X] sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      [ ] sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. 1 and the Supplemental Box.
   b. [ ] *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

[X]	Box No. I	Basis of the report
[ ]	Box No. II	Priority
[ ]	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
[ ]	Box No. IV	Lack of unity of invention
[X]	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
[ ]	Box No. VI	Certain documents cited
[ ]	Box No. VII	Certain defects in the international application
[ ]	Box No. VIII	Certain observations on the international application

Date of submission of the demand 12 September 2005 (12-09-2005)	Date of completion of this report 8 March 2006 (08-03-2006)
Name and mailing address of the IPEA/CA Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001(819)953-2476	Authorized officer Patrick Norman (819) 997-2156

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/CA2004/001971

Box No. I Basis of the report

1. With regard to the **language**, this report is based on:

[X] the international application in the language in which it was filed

[ ] a translation of the international application into , which is the language of a translation furnished for the purposes of:

[ ] international search (Rules 12.3(a) and 23.1(b))

[ ] publication of the international application (Rule 12.4(a))

[ ] international preliminary examination (Rules 55.2(a) and/or 55.3(a))

2. With regard to the **elements** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report):*

[ ] the international application as originally filed/furnished

[X] the description:

[X] pages	1 - 16 and 18 - 19		as originally filed/furnished
[X] pages*	17	received by this Authority on	12 Sept., 2005 (12-09-2005)
[ ] pages*		received by this Authority on	

[X] the claims:

[ ] pages			as originally filed/furnished
[ ] pages*		as amended (together with any statement) under Article 19	
[X] pages*	20 - 26	received by this Authority on	12 Sept., 2005 (12-09-2005)
[ ] pages*		received by this Authority on	

[X] the drawings:

[X] pages	1 - 16		as originally filed/furnished
[ ] pages*		received by this Authority on	
[ ] pages*		received by this Authority on	

[ ] a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing.

3. [ ] The amendments have resulted in the cancellation of:

[ ] the description, pages

[ ] the claims, Nos.

[ ] the drawings, sheets/figs

[ ] the sequence listing *(specify):*

[ ] any table(s) related to sequence listing *(specify):*

4. [ ] This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

[ ] the description, pages

[ ] the claims, Nos.

[ ] the drawings, sheets/figs

[ ] the sequence listing *(specify):*

[ ] any table(s) related to sequence listing *(specify):*

* *If item 4 applies, some or all of those sheets may be marked "superseded."*

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1 - 19	YES
	Claims	none	NO
Inventive step (IS)	Claims	1 - 19	YES
	Claims	none	NO
Industrial applicability (IA)	Claims	1 - 19	YES
	Claims	none	NO

2. Citations and explanations (Rule 70.7)

The following documents are referred to:

D1 - US4201467
D2 - US4402230
D3 - US6570647
D4 - US4251733

D1 describes an optical flow velocity meter for determining the average flow velocity of flue gases in a smokestack. A laser generates a beam of light which is split in two and passes through optics and then through the smokestack. Scattered light from articles in the smokestack are imaged by optics on the other side of the stack. The beams passing out of the stack are imaged onto two photodetectors after the light is passed through two high pass filters which serve to filter out the light from the gas flow and leave the scattered light from the particles. Cross correlation is performed to determine the transit time between the light beams from which the velocity is calculated . The flow is considered to be multi phase because of the gaseous and solid components, which are separated in the correlation and analysis.

D2 describes an apparatus for measuring flow velocity of individual flow components of a multi phase flow in a pipe. The device functions by using two probes (detectors) spaced apart along the length of the pipe. The probes are designed to detect the spectral energy of a two phase (liquid/gas) flow by detecting frequency information of the phase components. The device may be active or passive, the active type having transmitters of acoustic or optical energy which function with the detector probes. Probes may be either known optical, thermal or acoustic probes but the device is illustrated with acoustic probes. Each probe is connected to an amplifier which splits the signal into two channels, one for liquid phase and one for gas phase. Upstream and downstream filters which are matched to the frequency characteristics of the liquid and gas phase of the flow are attached to each probe. A cross correlation is connected to each channel to determine the transit delay of each of the liquid and gas phases between the two probes from which the velocity of each phase is calculated.

D3 describes an optical flow meter for determining concentrations or velocities in multi phase flows using backscattered, emitted or transmitted light. The device may measure in one or two dimensions using light, radiation or sonic waves. For measuring velocity, the device comprises two measuring heads which contains at least two optical fibers, one for transmitting the light and one for detecting the scattered light intensity. Times of flight are determined by correlating the signals from the two sensor heads and then the phase velocities are calculated using the optical distance between the sensor heads and the times of flight.

D4 describes an optical flow meter for measuring size and velocity of particles in a gas flow. The device consists of a laser which emits a beam that is split into two parallel beams and passed through a measuring chamber through which flows the gas and particles. The device can utilize forward or backward scattered light as well as light scattered at 90°.

continued in supplemental box

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

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Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

Continuation of: Box V

NOVELTY:

Amended claims 1 - 19 meet the requirements of novelty according to PCT Article 33(2). None of the cited documents disclose the features recited in the independent claims 1, 8, 14 or 17.

Because the independent claims exhibit novelty with regard to the prior art, the dependent claims are also considered to be novel.

INVENTIVE STEP:

Amended claims 1 - 19 meet the requirements for inventive step PCT Article 33(3). None of the prior art teaches or fairly suggests the combination of features recited in the amended claims.

INDUSTRIAL APPLICABILITY:

Amended claims 1 - 19 are considered to meet the requirements for industrial applicability. (PCT Article 33(4))

avalanche photodiodes (APD) as photodetectors 214, 216 if steam quality is approaching 100% or steam is superheated.

[0039] Light sheets 202, 204 may be provided at various locations within pipe 16. The sheets can be located in the center of the pipe, with the centerline velocity being measured using the cross-correlation technique. The centerline velocity must be converted into average velocity in order to calculate the total flow of the fluid. This conversion can be done by calculating the Reynolds number through known temperature and pressure of the fluid. Alternatively, the sheets can be located at ¼ radius from the pipe wall. This location eliminates the need for velocity conversion because the measured velocity at this point represents the integral velocity along pipe 16.

[0040] In addition to determining the flow velocity through cross-correlation calculation, the signal processing means for this embodiment may be used to calculate dispersion of the signals from photodetectors 214, 216. Figure 14A and Figure 14B show the signal from one of the photodetectors while monitoring steam moving at a speed of 20m/s and having a quality of 94% and 65%, respectively. Higher water content or lower steam quality resulted in increasing the signal dispersion from 0.52 to 0.97 in this example.

[0041] According to yet another embodiment, a collimated beam 230 is added to two light sheets as shown in Figure 15. The two light sheets are used to determine the flow velocity in a way as described above. Light from the collimated beam 230 is attenuated by the fluid flowing in pipe 16, and it is collected by an optical system 232 into a reference photodetector 234. In addition to velocity measurement using the cross-correlation technique, the signal processing means for this embodiment may be used to calculate dispersion of the signal from

WHAT IS CLAIMED IS:

1. A method for measuring the velocity of a multiphase fluid flowing in a pipe, the multiphase fluid comprising a liquid phase and a gaseous or solid phase, the method comprising:
   a. directing a pair of collimated beams of light from an illuminator through the multiphase fluid by means of transparent portions of the pipe, said pair of collimated beams spaced apart in a direction of flow of the multiphase fluid by a predetermined distance;
   b. detecting scattered, deflected and attenuated light with a pair of photodetectors to produce a pair of signals, each of said pair of photodetectors associated with one of said pair of collimated beams;
   c. calculating a cross-correlation function between said pair of signals to determine a time delay between the signals;
   d. calculating the average velocity of the multiphase fluid by taking the ratio of the predetermined distance to the time delay between the signals; and,
   e. passing the pair of signals through a plurality of band-pass filters to isolate a plurality of pairs of corresponding frequency components, each of the plurality of pairs of corresponding frequency components corresponding to one of a plurality of flow components.

2. A method according to claim 1 further comprising, for each of said plurality of pairs of corresponding frequency components:
   a. calculating a cross-correlation function between the pair of corresponding frequency components to determine a time delay between the corresponding frequency components; and,
   b. calculating the velocity of the corresponding flow component by taking the ratio of the predetermined distance to the time delay between the corresponding frequency components.

3. A method according to claim 2 further comprising determining an intensity of each of said pairs frequency components and calculating an amount of a corresponding one of said plurality of flow components from said intensity.

4. A method according to claim 3 further comprising determining a flow rate of each of said plurality of flow components by multiplying the velocity of each flow component by the intensity of the corresponding pair of frequency components.

5. A method according to claim 4 wherein a vapour fraction of said multiphase flow is calculated as a flow rate of a fastest one of said plurality of flow components.

6. A method according to claim 5 further comprising determining a total flow rate of said multiphase flow by summing the flow rates of all of said plurality of flow components.

7. A method according to claim 6 further comprising calculating a quality of the multiphase flow by taking a ratio of the vapour fraction to the total flow rate.

8. An apparatus for measuring the velocity of a multiphase fluid flowing in a pipe, the multiphase fluid comprising a liquid phase and a gaseous or solid phase, the apparatus comprising:

   a. an illuminator for generating a pair of collimated beams of light and directing said beams through the multiphase fluid by means of transparent portions of the pipe, said pair of collimated beams spaced apart in a direction of flow of the multiphase fluid by a predetermined distance;

   b. a pair of photodetectors positioned across the pipe from said illuminator, each of said pair of photodetectors optically associated

with one of said pair of collimated beams for detecting scattered, deflected and attenuated light from the associated beam and generating a signal; and,

c. a signal processing means for processing the signals from said pair of photodetectors and calculating cross-correlation functions between the signals to determine a time delay, and for calculating the velocity of the multiphase fluid by taking a ratio of the predetermined distance to the time delay, said signal processing means comprising a plurality of band-pass filters for isolating a plurality of frequency components of each of the pair of signals.

9. An apparatus according to claim 8 wherein said illuminator comprises a first illuminator for generating a first pair of collimated beams, and wherein said pair of photodetectors comprises a first pair of photodetectors, the apparatus further comprising:

a. a second illuminator for generating a second pair of collimated beams of light and directing said second pair of beams through the multiphase fluid at an angle to said pair of beams generated by said first illuminator; and,

b. a second pair of photodetectors positioned across the pipe from said second illuminator, each of said second set pair of photodetectors optically associated with one of said second pair of collimated beams for detecting scattered, deflected and attenuated light from the associated beam and generating a signal,

wherein said signals from said second pair of photodetectors are processed by said signal processing means.

10. An apparatus according to claim 9 wherein the angle is perpendicular.

11. An apparatus according to claim 9 further comprising at least one optical system for focusing light scattered at a near perpendicular angle from said

pair of collimated beams from at least one measurement zone onto at least one photodetector.

12. An apparatus according to claim 8 further comprising a multi-focal optical system for focusing light scattered at a shallow angle from said pair of collimated beams from a plurality of measurement zones onto a plurality of photodetectors.

13. An apparatus according to claim 8 further comprising a multi-focal optical system for focusing light scattered at a near 180 degree angle from said pair of collimated beams from a plurality of measurement zones onto a plurality of photodetectors.

14. A method for measuring the velocity of a multiphase fluid flowing in a pipe, the multiphase fluid comprising a liquid phase and a gaseous or solid phase, the method comprising:

(a) directing a pair of light sheets from an illuminator through the multiphase fluid by means of transparent portions of the pipe, said pair of light sheets oriented perpendicular to a direction of flow of multiphase fluid and spaced apart in the direction of flow by a predetermined distance;

(b) detecting scattered and deflected light with a pair of photodetectors to produce a pair of signals, each of said pair of photodetectors associated with one of said pair of light sheets;

(c) calculating a cross-correlation function between said pair of signals to determine a time delay between the signals;

(d) calculating the average velocity of the multiphase fluid by taking the ratio of the predetermined distance to the time delay; and

(e) calculating an amount of liquid fraction in the multiphase fluid based on dispersion of signals from said photodetectors.

15. A method according to claim 14 further comprising:
   (a) directing at least one collimated beam in a direction generally parallel to said pair of light sheets;
   (b) detecting deflected and attenuated light from said collimated beam with a reference photodetector to produce a signal associated with said collimated beam; and,
   (c) calculating the amount of liquid fraction in the multiphase fluid based on dispersion of the signal from said reference photodetector.

16. A method according to claim 14 further comprising:
   (a) directing at least one collimated beam in a direction generally parallel to said pair of light sheets, said collimated beam comprising light of a first wavelength with high absorbance in a liquid fraction and light of a second wavelength with low absorbance in the liquid fraction;
   (b) detecting attenuated light with reference photodetectors to produce a first signal corresponding to light of said first wavelength and a second signal corresponding to light of said second wavelength; and,
   (c) calculating the amount of liquid fraction in the multiphase fluid based on a ratio of said first and second signals.

17. An apparatus for measuring the velocity of a multiphase fluid flowing in a pipe, the multiphase fluid comprising a liquid phase and a gaseous or solid phase, the apparatus comprising:
   (a) an illuminator for generating a pair of light sheets and directing said light sheets through the multiphase fluid by means of transparent portions of the pipe, said pair of light sheets oriented perpendicular to a direction of flow of multiphase fluid and spaced apart in the direction of flow by a predetermined distance;
   (b) a pair of photodetectors positioned across the pipe from said illuminator, each of said pair of photodetectors optically associated

with one of said light sheets for detecting scattered light from the associated light sheet and generating a signal; and,

(c) a signal processing means for processing the signals form said pair of photodetectors, calculating cross-correlation functions between the signals to determine a time delay, calculating the velocity of the multiphase fluid by taking a ratio of the predetermined distance to the time delay, and for calculating an amount of liquid fraction in the multiphase fluid based on dispersion of signals from said photodetectors.

18. An apparatus according to claim 17 further comprising:

(a) a reference illuminator for generating a collimated beam and directing said collimated beam through the multiphase fluid by means of transparent portions of the pipe;

(b) a reference photodetector positioned across the pipe from said reference illuminator and optically associated with said collimated beam for detecting attenuated light from said collimated beam and generating a signal, and;

(c) a reference signal processing means for processing said signal from said reference photodetector and calculating the amount of liquid fraction in the multiphase fluid based on dispersion of said signal.

19. An apparatus according to claim 17 further comprising:

(a) a reference illuminator for generating a collimated beam and directing said collimated beam through the multiphase fluid by means of transparent portions of the pipe, said collimated beam comprising light of a first wavelength with high absorbance in a liquid fraction and light of a second wavelength with low absorbance in the liquid fraction;

(b) reference photodetectors positioned across the pipe from said illuminator and optically associated with said collimated beam for

detecting attenuated light from said collimated beam and generating a first signal corresponding to light of said first wavelength and a second signal corresponding to light of said second wavelength, and;

(c) a reference signal processing means for processing said first and second signals and calculating the amount of liquid fraction in the multiphase fluid based on a ratio of said first and second signals.